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Broadband development in Denmark

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1. Introduction

Information and communication technology (ICT) is seen as a driver of economic development, and broadband is considered as one of the crucial areas in this regard (European Commission, 2010; Kim et al., 2010). Since the breakout of the financial and economic crisis in 2008, broadband has come even more to the fore as a key area for re-boosting the economy (Falch & Henten, 2010).

The increased focus on broadband also applies to Denmark. Following a number of initiatives in other countries to promote broadband development, a High Speed Committee in Denmark issued a report in early 2010 having as its central recommendation to put the main focus on the development of services and applications instead of infrastructure development (Højhastighedskomiteen, 2010). Ironically, the main political outcome was that the Danish Government announced a goal to reach '100 Mbps or more for all households and enterprises by 2020' (NITA, 2010).

The aim of the paper is to analyze the market and policy developments with respect to broadband in Denmark. The Denmark country case story is no more and no less interesting than all other case stories regarding national broadband developments. The lessons to be learned from such a case story relate to the interplay between the general features and the specifics of the particular national development. In order to draw any general conclusions, it is necessary to analyze the specificities of the developments in individual countries.

The special areas of interest featured in the paper are primarily concerned with the relationships between the supply of broadband infrastructures and the demand for the applications and services requiring broadband capacity. Moreover, the Danish case is characterized by an incumbent operator, TDC, which has a presence in the market using all important broadband technologies, DSL, cable, fiber, and mobile. The implications of this situation are examined. In addition, the implications of the fact that the Danish incumbent operator for a number of years has been owned almost entirely by private equity are briefly discussed. Furthermore, the Danish version – so to say – of the general move from an emphasis on creating competition in the broadband market towards focusing on building new infrastructures is taken up. This relates to the long-standing discussion on infrastructure versus service competition.

In international comparative statistics, Denmark has all the while been at the forefront with respect to penetration per 100 inhabitants (e.g. OECD), and in broader comparisons of ICT developments, for instance Economist Economic Unit's 'Digital Economy Rankings' (Economist Economic Unit, 2010) and 'The Global Information Technology Report' of the World Economic Forum (2011), Denmark has constantly featured at the top of the rankings. On the other hand,

broadband speeds in Denmark are on an average level in an international context, and prices are not among the cheapest. These characteristics could in themselves be a reason for an interest in the Danish broadband case but are only interesting when seen in connection with the market and policy developments in Denmark. This is the ambition of the present paper, namely to examine the salient features of the Danish broadband development in light of the characteristics of the market and policy developments in Denmark.

The sections that follow are first a brief account of the methodological approach. After this, there is an overview of the general policies and policy initiatives addressing broadband developments. Thereafter, the focus shifts to the more specific regulatory interventions. Following this, selected aspects of market developments including strategic actions of broadband providers are analyzed, succeeded by a section on the use perspective. Finally, these different approaches are summarized in a discussion and conclusion section.

2. Methodology

The approach used in the paper is institutional. More specifically, the approach is inspired by what is often termed old or traditional institutional economics with Thorstein Veblen (1973, first published in 1899) and John R. Commons (1934) as important early contributors. The reason for choosing this approach is that it provides a basis for an explorative and inductive approach, which resonates well with the aim of the present country case study.

The simplified methodology used in the present paper is to examine the factors and actors affecting the development of broadband. The many and complex interrelationships between the factors and actors affecting the development of broadband are not the focus of the analysis. The same applies to the internal dynamics in each of these types of factors/actors. Only the direct effects on broadband development are analyzed, and in this context, emphasis is given to policy and regulation. Furthermore, the internal dynamics among the actors deploying broadband are examined, e.g. competition between network operators.

This means that the 'dependent variable' is the activities of the network operators of different kinds: Telecom operators, cable operators, and providers deploying fiber networks. The 'independent variables' are the following, and emphasis is on the last three bullets.

- *Factor*: technology development; *actors*: equipment (hardware and software) providers
- *Factor*: demand; *actors*: business, residential and government users
- *Factor*: content provision; *actors*: content (services and applications) providers
- *Factor*: policy and regulation; *actors*: policy makers and regulators

The conceptual framework for the analysis is concerned with the institutional actors and the laws and regulations and how these influence the development of broadband in Denmark. Actors, laws and regulations should not be looked upon in isolation from one another. The approach puts focus on the interplay between the institutional actors and the institutions that laws and regulations constitute and, consequently, takes a systemic point of view including not only the formal rules and regulations but also the informal determinants of market developments. As the paper is concerned with the developments of a technological infrastructure, the interest is on the interrelationships between technology developments, market developments, and the policies and regulations in the area. Furthermore, the interest is not only on the infrastructural aspects but also on the uses of these technologies, as this is crucial for the development of broadband.

As the paper is concerned with development issues, a historical perspective is used. This facilitates a discussion on the likely future developments of broadband in Denmark. As far from all important aspects of the development can be included in the analysis, focus is on the critical incidents and the major factors and actors affecting the developments. Such an approach presupposes that the development of broadband is not always a continuous trajectory but includes important turning points, where new factors and actors affecting developments enter the 'game' or where changes in the relationships between technology, market, and policy take place. To the extent possible, it is therefore attempted to establish a periodization of the development of broadband in Denmark.

3. Policy initiatives

The present and the following section examine the policies, politics and regulations affecting broadband development. Policies denote the policy statements and positions based on political ideologies made and taken by actors of different kinds. Politics are the actual realized policies, meaning primarily the laws being enacted. Regulations are a sub-group of politics in the sense that regulations are the laws and ministerial orders, which require regulatory interventions. The reason for differentiating between these concepts, oftentimes used interchangeably, is that most countries have developed 'beautiful' policies regarding ICT and broadband development but have done relatively little with respect to realizing these policies in terms of politics and regulations.

Often the role of policy is overestimated concerning the effects on the actual development in the ICT and broadband development field – and other fields as well. Once a 'beautiful' policy has been formulated, very little happens afterwards. The political pressure has been taken off and only bits and pieces go into the actual political process. It is, consequently, not sufficient to look at policy statements in order to get a picture of the role of policy and regulation in relation to ICT and broadband developments. It can be helpful in terms of determining the direction of political initiatives. However, the realized politics and regulations are the most important elements to study.

In terms of realized politics and regulations, there have been two main manners of affecting broadband developments in most countries. One manner – and the politically generally most accepted manner – is to construct a regulatory framework setting the rules for market developments implemented ex ante or ex post. The other main manner is to invest public money in building/extending infrastructure. This manner has generally been less accepted politically in a liberalized market situation. However, for the sake of limiting digital divides, for instance between urban and rural areas, public investments are accepted. And, the same apparently applies to situations of general economic crisis – as the latest financial and economic crisis has demonstrated (Falch & Henten, 2010).

In Denmark, however, there is and has been very little public money going into building/extending broadband infrastructures. Two of the recent exceptions have been the public research and education network and a few municipalities having used public money for local broadband initiatives. Generally, broadband infrastructure construction has after the liberalization in the mid-1990s been left to private enterprises, and the political influence has been exercised through the setting of a regulatory framework and through policy initiatives mainly on the demand side.

Since the mid-1990s there has been a range of policy plans and initiatives in the information and communication technology area broadly speaking, and during the last decade broadband development has been a specific target area. It is not possible to focus solely on the initiatives relating to broadband, as the broader information and communication technology policies are completely intertwined with the more specific broadband initiatives.

The first broad policy statement announcing a fundamental change in the ICT policies in Denmark came in 1994 in a report entitled 'Informationssamfundet år 2000' ('The information society year 2000') (Forskningsministeriet, 1994). The report aimed at presenting a vision/project for how 'modern information technology will bind together public institutions and businesses and constitute a proposition to the citizens' (Forskningsministeriet, 1994). One year later, the ministry of research (Forskningsministeriet) issued a report entitled 'Bedst og billigst gennem reel konkurrence' (Best and cheapest by way of real competition') (Forskningsministeriet, 1995), which came to function as a kind of blueprint for the process of liberalizing the Danish telecommunication market.

While Denmark in the late 1980s and first part of the 1990s 'dragged its feet' with respect to reforming its telecommunication market, the government, led by the social democrats at that point of time, saw 'the writing on the wall' with information society plans and suggestions for reforming the telecommunication area coming out of the US and the European Commission. The decision was made to take a proactive stance to the potentials in information and communication technologies and to reforming the telecommunication market. This was in a sense a radical innovation of the Danish policies in the area – a radical innovation which has subsequently been followed by many and continuous incremental additions.

There has been and is a broad political consensus around the general information and communication technology policies and the more specific telecommunication related policies. There are no major differences in these policy areas between the liberal or right wing parties, on the one hand, and the social democratic or left wing parties, on the other. More specifically, and as an example, the telecommunication policy in Denmark is backed by all major parties and builds on an agreement of principle from 1999 – which is based on EU policy in the area. The general policy trend has been not to intervene by way of public investments on the supply side but to focus on policy initiatives on the demand side in terms of public use of communications infrastructures and public services requiring internet access. This implies public support for the development of service and application areas related to public sector functions and institutions. The policy is thus demand and service oriented.

Following up on 'The information society year 2000' report from 1994 and the policy agreement from 1999, each year since 2000 the government has published a so-called IT and telecommunication policy review. These reviews are reports on the political initiatives and activities of the past year and a summary of political initiatives for the coming year. The general policy direction of these reviews has been consistent over the years. They are based on the understanding that infrastructure and service development initiatives support each other and are mutually interdependent. This means that when services requiring higher bandwidths are developed and taken up by the market, more powerful broadband infrastructures have to be built – and will be built by market actors, is the philosophy. It also means that more powerful broadband infrastructures will facilitate the development of more bandwidth consuming services and applications. However, the Danish policy has been and is to intervene in this interdependent relationship by way of promoting the service side.

By the government itself, this policy has been termed as technology neutral and market oriented. Such a characterization is obviously self-congratulatory to some extent, as the overall policy and regulatory framework favors some kinds of infrastructures developments over others and specifically favors certain technology developments in the wireless broadband area. However, the characterization is correct in the sense that public money is not allocated for the development of specific types of network infrastructures.

This does, on the other hand, not mean that there is no kind of political 'activism' to promote broadband developments. But the initiatives are on the services and demand side. This includes the promotion of G2G e-government, i.e. the use of ICT internally in public administrations and between public administrations in different areas and at different levels. But more importantly for broadband development, it also includes the promotion of electronic communications between public administrations and citizens and businesses. An example of such initiatives is that public administrations do not accept paper based invoices from companies with which they do business. Another example is that tax reporting between the taxing authorities and citizens and companies will be all electronic from 2012 – however with possibilities, for instance, for elderly who do not

use internet to communicate with the taxing authorities otherwise. Also, from 2012 all students applying for enrollment at higher educational institutions must do this electronically. And, a last example is the cooperation of a public-private-partnership type between the state and financial institutions regarding identity management in electronic communications. One and the same identity management system is used in electronic communications between citizens and public administrations and for electronic banking. The implications of such initiatives are that there is increased pressure on citizens and companies to communicate electronically and, therefore, to use broadband connections.

A characteristic example in this context was a broadband policy initiative presented in 2010. This initiative was launched on the background of a general international surge of broadband plans in connection with the financial and economic crisis starting in 2008. In Denmark, a High Speed Committee was established to examine whether initiatives needed to be taken to support broadband development. The results of the deliberations of the committee illustrate the general political priorities in Danish ICT and broadband policies. Seven areas of policy initiatives were given priority. The first two were digitalization of the public sector and the public sector as platform for innovation. This was followed by suggestions regarding the development of cloud computing and information and IT competences. After this came initiatives regarding the environment, climate and green IT and research and development in the IT area. As the last item came initiatives regarding broadband development, and the suggestions were concerned with supporting broadband by strengthening the demand side. There were no suggestions for using public money for broadband development.

The irony of the matter was that even though this was well in line with longstanding Danish ICT and broadband policies, the minister responsible for the ICT area at that point of time apparently felt that something more had to be done. Therefore, a policy statement was issued saying that by 2020 '100 Mbps or more for all households and enterprises' would need to be available. However, there was no economic backing for this goal. It was merely an expression of intent for the market players to realize. The only tangible political measure to realize this goal is concerned with requirements regarding coverage on operators in connection with license auctions for mobile broadband frequencies. In addition, the minister announced a constant 'political attention' to broadband development – which is rather intangible but nevertheless may put pressure on operators to make available higher broadband speed to everyone.

4. Regulation

Like other EU countries, Denmark must comply with the general EU rules in the area. The liberalization process in Danish telecommunication regulations must, therefore, be seen in the context of the process of liberalization of telecommunication at the EU level. However, as EU telecommunication policies are mainly issued in the form of directives to be transposed to the

national level, there are differences in the mode of implementation and, consequently, the specific national rules and schedules for implementation as well.

In Denmark, the liberalisation process can be divided in different phases. The first phase started in the mid-1980s and ended in the mid-1990s. The second phase ended in 1999, where a third phase began. Whether this third phase is presently reaching its end is an open question. At a broader international scale, there seems to be an increasing focus on building new infrastructures and less on creating competition in the markets. This could signal a new turn in telecommunication policies but has not yet materialized in the Danish context.

The first phase began in the 1980s resulting in the liberalization of customer premises equipment (CPE) by 1990. However, in this early phase and in the beginning of the 1990s, the Danish government was reluctant to infringe upon the powers and privileges of the incumbent (formed by merging the former regional monopoly operators and a state-owned international operator in 1990), and the liberalization process was mainly driven by the requirements from the European Commission.

The primary exception was mobile communications. Two operators were licensed to operate mobile networks in Denmark in 1991. The incumbent got one license, and the other went to a company named Sonofon, which was later taken over by Telenor. The reason for the mobile exception was that mobile, at that point of time, was not considered an essential part of the telecommunication area. Fixed line communication constituted the cornerstone of the telecommunication business. However, this protective policy towards the fixed line interests of the incumbent changed in the mid-1990s.

In 1995, the government issued a policy strategy report entitled 'Best and cheapest by way of real competition' (Telestyrelsen, 1995). In spite of various qualifications made since then, this overall policy strategy is still valid. Competition on the Danish market was to be promoted through an early liberalization combined with a rather strict competition regulation. The idea was that Denmark should be among the first countries in Europe to liberalize its telecommunication market and, thereby, attract foreign investments.

Therefore, the Danish parliament made a decision aiming to complete the liberalization process for services and infrastructure 18 months ahead of the target to liberalize the European telecommunication markets by 1998. Since then it has been a priority to stimulate competition and the Danish telecommunication legislation has in most areas been ahead of the requirements set by the European framework regulations.

4.1 Access and interconnection

Whereas there was infrastructure competition in the mobile area, the emphasis was on service based competition in the fixed network market, and a key issue was to ensure open access and

low interconnection charges in order to enable new entrants to compete with the incumbent operator TDC. The Interconnection Act was passed, stipulating *inter alia* that operators with a significant share of the market (that is to say more than 25%) were to grant interconnection to other operators at cost-based prices and on terms that were objective, transparent and non-discriminatory.

The principles for interconnection introduced in 1996 were based on historical costs. The principle was to allow the inclusion of the total extra costs related to the provision of the service plus a reasonable margin. However, if the dominant operator (i.e. TDC, the incumbent carrier) had a market share of more than 80%, only 30% of the operating costs should be included. This implied that the incumbent operator should bear a part of the interconnection costs until the new entrants had obtained a reasonable market share. In this way, the incumbent was required to subsidize its competitors until some of them had established themselves on the Danish market (Falch, 2002). This approach was compatible with the investment ladder strategy stylized by Martin Cave (2006).

Another initiative taken in order to promote competition was unbundling of the local loop. This was introduced in 1998, when Mobilix (Owned by France Telecom) wanted to introduce ADSL before this service was available from TDC.

In order to ensure low interconnection rates, the historical cost approach was supplemented by a best practice clause in 1998, enabling the national telecommunication regulator to reduce interconnection charges to the international level for best practice even if TDC was able to document that the actual costs were higher. The definition of best practice was subsequently changed after several debates between the telecommunication agency, TDC and the new entrants. Best practice came to be defined as the average of the interconnection rates in the three countries with the lowest interconnection rates. It was also possible for the regulatory agency to reduce rates if they were lower in just one country. However, in this case corrections for country specific conditions should be made in advance. By definition the best practice clause kept the Danish interconnection rates among the lowest in Europe and the charges were reduced to one third within five years.

The next phase followed the political framework agreement signed in September 1999. During this phase, the government added to the 'best and cheapest' policy the goal of promoting public access to the network society. Fostering competition was seen as the principal means to achieve this goal through initiatives aiming to stimulate the creation of competing access routes for consumers ('several pipes to the home').

In July 2000, much of the existing legislation for the telecommunication sector was consolidated into the Act on Competitive Conditions and Consumer Interests in the Telecommunications Market. By the adoption of the new legislation, it was decided that interconnection rates in the future should be based on LRAIC. The regulatory agency, therefore, initiated the construction of a

cost model for the Danish telecommunication network, building on the LRAIC concept. Interconnection charges, set on basis of the LRAIC model, took effect from 1 January 2003. Ordinary interconnect charges were reduced by 17-36%, but the LRAIC price calculated for raw copper was 24% above the current price at the time. It was, therefore, decided to implement the price increase on raw copper over a period of seven years. This has implied that the interconnection charges have increased from being among the lowest in Europe to be close to the EU average.

Table 4.1: Average total cost per fully unbundled loop (Euro per month), 2002 and 2009

	2002	2009
Denmark	12.1	11,34
EU average	22.6	9.76

Sources: EU: Telecommunications Regulatory Package – VIII Implementation report – Annex I – Corrigendum March 2003, Telecommunications Regulatory Package – XII Implementation report – Annex I, 2010.

It can be argued that the LRAIC approach for calculating the interconnection rates is objective and scientific. Still, there is plenty of room for discretion in the price setting. In Denmark, the LRAIC modeling was elaborated in collaboration with TDC as well as a group of new entrants. The new entrant group was dominated by mobile operators and their primary interest was to ensure low rates for fixed termination of mobile calls. Furthermore, an increase in prices for raw copper was in accordance with the ‘several pipes to the home’ strategy as it would presumably promote infrastructure investments by alternative operators. It would, therefore, be in line with an investment ladder strategy, as increasing interconnection charges were supposed to incentivize new operators to invest in new infrastructure instead of relying on old infrastructure owned by the incumbent.

While the price regulation of wholesale broadband services has become less strict than at the turn of the century, the regulation in other areas regarding open access is broader in its scope than in most other European countries. The telecom legislation does not distinguish between different types of fixed communication networks. This implies that the same regulation applies to copper, cable and optical networks, and an SMP operator can be requested to open any network regardless of the technical platform used.

The inclusion of cable and optical networks is a relatively new thing. In December 2009, the regulatory agency required TDC to open their cable network enabling other operators to use this infrastructure for the provision of broadband services. The implementation of this, however, awaits the preparation of an LRAIC pricing model for cable TV networks.

Since June 2011, TDC has also been demanded to open up its fiber based broadband access network for other operators and service providers. This applies not only to the current subscribers

of TDC, but also to homes passed. Potential broadband subscribers can demand to be connected to TDCs optical network if the network passes their home in a distance of less than 30 meter. The costs of connection, which are estimated to be around €2,000, must be paid by TDC – even if the customer wants to subscribe to a competing operator.

One can argue that the Danish regulation in the field is in line with the technology neutrality principle recommended by the EU Commission (CEC, 2007). However, the Commission does not recommend including fiber and cable networks in the definition of the market for broadband access (market 5). Denmark is, indeed, not the only country that applies a definition that deviates from the EU recommendation on this point. Cable access is included in market 5 in 11 other EU countries (Valcke et al., 2011). However, Denmark is the only country, where this has been followed by a request to an operator to provide open cable as well as fiber access.

4.2 Universal service

While access and interconnection regulation has changed during the different phases of liberalization, universal service policies have remained constant. Potentially, universal service provisions can be used for extending broadband but has not been used to that effect in Denmark.

Since the implementation of a universal service obligation in 1996, TDC has, as the incumbent operator, been appointed as the universal operator in all markets. Denmark included from the beginning data services in the service obligation, as TDC had an obligation to provide ISDN and leased lines in addition to provision of ordinary phone services. The current legislation does, however, not specify any particular data network services but includes just access to a public electronic communication network at a fixed location (not necessarily a wired connection). Voice telephony is the only service, which is specifically mentioned in the universal service legislation. However, the Minister can include other communication services if they are widely available but not to all.

The development of the coverage of broadband services has been followed closely by the regulatory agency, but a universal service obligation for broadband services has not been considered, though it could be an option if coverage does not develop satisfactorily. The abovementioned obligation on connection of homes passed is not a part of the universal service regulation, but is included in the regulation of open access.

4.3 Frequency regulation

The first 3G licenses were auctioned in 2001. This was the first time that an auction was used for assignment of spectrum in Denmark. Four licenses were issued: Three went to existing 2G mobile operators: TDC, Telia, and Orange (formerly Mobilix). The fourth license went to Hi3G – a new operator at the Danish market. The fourth 2G operator Sonofon (later Telenor) applied for a

license as well, but did not succeed. However, they were granted a license in 2005, when a license became vacant due to the merger of Telia and the Danish affiliate of Orange.

In May 2010 spectrum in the 2.5 GHz band was completed and TDC, Telenor, Telia and Hi3G were granted a license each, which can be applied for the provision of LTE services. More spectrum in the 800 MHz band freed as a result of the digital dividend will be used for mobile broadband services and will be assigned from January 2013.

4.4 The phases of regulation

The phases of telecommunication regulation in Denmark are clearly related to the phases of the telecommunication policies of the EU – but now and then Denmark has been a laggard and now and then ahead. As in most other countries, the liberalization process started with CPEs and with the licensing of an alternative mobile operator. After the EU 1987 Green Paper, Denmark was among the hesitant countries up until a rather abrupt change in the mid-1990s. Suddenly the Danish telecommunication regulation took a leap into the liberalization process in advance of the EU 1998 liberalization deadline.

In 1997, the EU issued a Green Paper on the convergence of communication technologies. The markets were increasingly developing from vertical to horizontal structures, and different infrastructures could deliver essentially the same services. One of the implications was a greater emphasis on promoting different infrastructures in order to create ‘real’ - meaning infrastructure – competition instead of just service competition. In Denmark, this found an expression in the political aim of ‘several pipes to the home’. While up until then, focus had been on creating service competition by way of interconnection and access regulation, the promotion of infrastructure competition came to play an increasing role.

This did not mean that the aim of advancing service competition was abandoned. The policy ‘went on two legs’ and the manner in which the promotion of service competition as well as infrastructure competition was reconciled conceptually was by seeing increased service competition as a road to infrastructure competition – what came to be called the ladder of investment.

Lately, however, the contours of a new phase seem to be appearing internationally. This phase puts less emphasis on the creation of competition and more emphasis on infrastructure construction. The reason is that it has turned out to be difficult to create infrastructure competition and that the companies investing in new infrastructures (fully or partly optical networks) are complaining that there is no incentive to invest if competitors can get access to the new networks on equal terms. The Danish incumbent TDC has also argued in that manner. However, the actual present Danish access and interconnection regulation includes not only copper but also cable and optical networks. This is an exception in the EU context, and the best

explanation for this state of affairs is that TDC has a stake if not dominates all fixed infrastructures – which is examined in the following chapter.

5. The Danish broadband market

In this section, the coverage, penetration, trends in user prices, competition on the wholesale market, competition on the retail market, and future perspectives are examined. But first, there is an introduction to the ‘pre-history’ of broadband in Denmark – the so-called hybrid network.

5.1 The hybrid network

The first initiative to invest in broadband facilities was taken already back in 1985, when it was decided to build a so-called hybrid network. This network had a dual purpose: 1) to provide private households, connected to a cable TV network, with TV and radio channels, 2) to provide private companies and public institutions with high-speed data channels (mainly for the purpose of two way video-transmission). Four out of 12 fibres were dedicated for radio and TV broadcast, four fibers for the high-speed network, and the remaining four fibers were reserved for future use. The project was initiated as a public investment but was foreseen to be self-financing within 6-7 years.

The idea with this shared infrastructure was to pave the way for a fully integrated broadband network by sharing the costs with cable TV subscribers (Østergaard, 1986). In addition, the project was seen as a support for Danish industry (Prehn, 1986). The network was in the initial phase based on the Danish DOCAT (Digital Optical Community Antenna Trunk) standard, and the large Danish producer of cables, NKT, lobbied strongly for the project. Thus, the hybrid network would create more demand for Danish produced telecommunication equipment and, at the same time, provide Danish industry with access to new advanced communication services.

However, the number of companies using the hybrid network as a communication facility remained extremely limited and the network, in reality, became a cable TV network. In 1995, the network was closed down as a separate network and integrated into the Tele Denmark (later TDC) network. Today the most important remaining impact of the hybrid network is that it allowed the regional telecommunication operators, who later formed Tele Denmark to engage in the provision of cable TV services – a market they up till then were denied by regulation.

5.2 Coverage

Currently, Denmark has a broadband coverage close to 100% of at least 512 kbps. The policy ambition is that all citizens should have access to 100 Mbps by 2020. In 2010, only 25% of the population had that opportunity. 92% had access to 10 Mbps and 99% had access to 2 Mbps - compared to only 40% in 2006 (ITST, 2010).

Table 5.1: Estimated coverage of households by download and upload capacity (in %), 2010

Capacity	Download	Upload
512 kbps	99.95	99
2 Mbps	99	90
10 Mbps	92	90
30 Mbps	74	30
50 Mbps	68	29
100 Mbps	25	24

Source: IT og telepolitisk redegørelse 2010

At least four different access technologies are available for the vast majority of the population. xDSL is the most widespread technology covering 99% of the population. 3G has a similar level of coverage but the capacity is much lower. xDSL has from the beginning been the most important technology applied to offer widespread access to broadband services. ADSL was introduced as a service medio-1999. Coverage developed rapidly to include the majority of the population and already by 2003 coverage reached 90%.

Cable as an infrastructure for broadband services was introduced one year later. Also in this case, coverage developed rapidly. In 2003, most of the cable infrastructure was upgraded to provide broadband services. Cable coverage is, however, limited by the fact that the cable networks only cover parts of the population. Coverage of wireless services has developed even faster due to lower investment costs and a higher level of competition.

It follows that apart from fiber, all access technologies have succeeded in gaining a high level of coverage few years after their introduction on the Danish market. This is partly a result of a deliberate policy, partly due to the socio-economic environment. Universal coverage of broadband services has been a policy goal for more than a decade, and regulation has favoured a high level of coverage.

The Danish telecommunication regulation does not provide for a universal service obligation beyond telephony and a workable data connection, as it does in Sweden and Finland, but the mere formulation of universal coverage of broadband services as a policy goal has put pressure on especially TDC to provide extensive coverage of their services.

In addition, Denmark is a high income country, where households rapidly take up new technologies. Furthermore, the Danish geography implies that the investments needed for coverage of the majority of the population are affordable for most network technologies – at least compared to the investments needed in other Scandinavian countries.

Table 5.2: Broadband coverage, 2001-2010

Access Technology	% of population covered		
	2001	2005	2010
xDSL	64	98	99
Cable	14	60	61
Fibre	0	9	31
3G	0	90	99
FWA including WiMAX	90	90	76
LTE	-	-	98 *
Total		>98	100

*) LTE is introduced in December 2010 and 98% coverage will be achieved ultimo 2011.

Source: Bredbåndsredegørelsen, 2010, Computerworld 9. December 2010.

An interesting phenomenon that, at a point of time, contributed to the expansion of coverage is the emergence of local community based alternative network providers. These operators have been established in order to serve a market need in primarily rural areas, where services provided by the major operators were either inadequate or very expensive. One example of such a network provider is Djursland.net. Djursland.net took off in year 2000, when the development of a wireless broadband network covering a population of 82,000 began.

This network was once one the largest alternative broadband operators in Europe. The organization was dissolved in 2009, but the network facilities are still in operation <http://www.djurslands.net/> (accessed August 2011). Presently, this type of alternative networks is less important, as coverage of competing solutions has improved. Moreover, some of these networks have been taken over by Dansk Bredbånd, which later on was bought by Waoo! – a broadband company owned by a cooperation of local energy companies. However, the alternative networks have played a role in establishing an early coverage in rural areas.

The coverage of fibre connections has developed at a slower pace than the coverage of any other access technology. This is primarily due to the high costs related to implementation of FTTH, but it is also a result of the expansion strategy chosen by TDC. TDC gradually replaces their copper based network with fibre based network facilities in a way that the optical part of the network and the DSLAMs move still closer to the end customer. It is, therefore, the alternative providers, mainly energy companies, that provide the major share of the fibre access connections. However, TDC is also active on this market as they have acquired a fibre network covering the capital region of Denmark built by the regional electricity company DONG.

5.3 Penetration

The penetration of broadband in Denmark was 38.2 per 100 inhabitants by end 2010. 74% of the private households have access to broadband compared to 44% in 2005. This makes Denmark one

of the countries with the highest penetration in the world. xDSL is the most popular technology, but fibre is gaining in importance, and the penetration of fibre connections is one the highest among European countries following Sweden, Norway and Estonia. Still, Denmark is far behind Japan and Korea.

Table 5.3: Penetration by technology, 2002-2010

	2002	2005	2010
xDSL	307,000	837,000	1,243,000
Cable	134,000	462,000	559,000
Fiber	18,000	117,000	171,000
Mobile broadband subscriptions	-	-	3,441,000
FWA including WiMAX	1,500	4,800	49,000

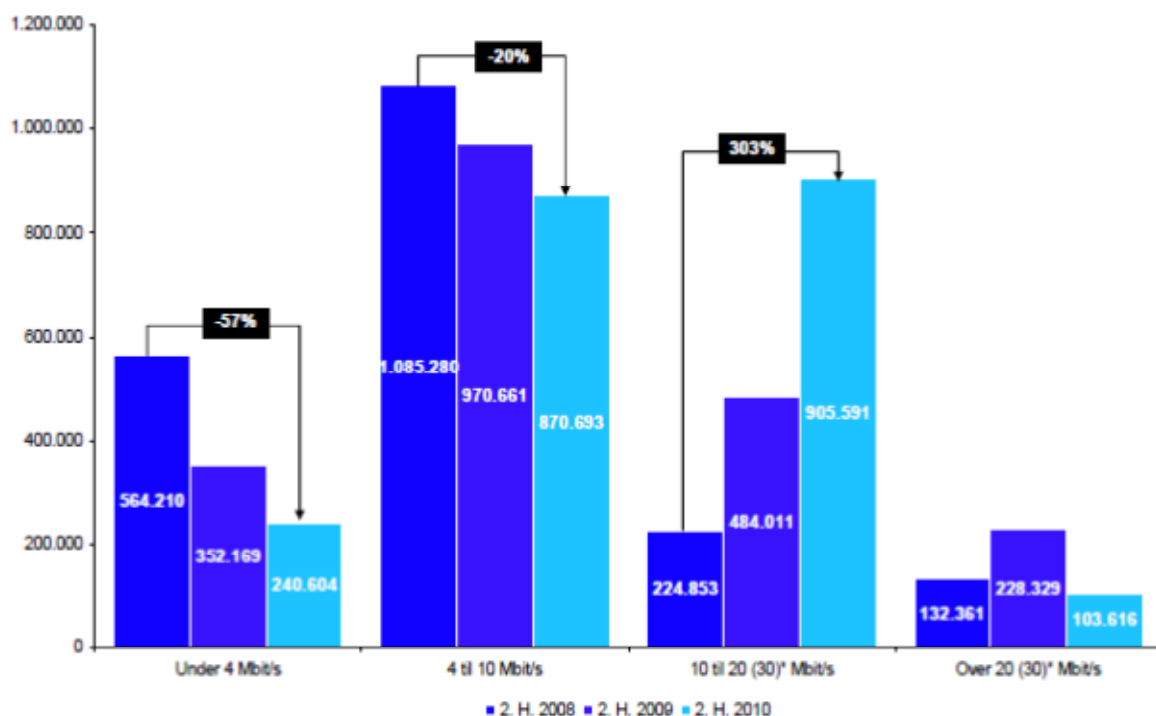
Source: ITST

The penetration is uniform across regions, but the take-up is slightly above average in the capital region and slightly below average in Southern Jutland. These minor differences seem to be due to differences in demography rather than differences in availability of broadband services.

The demand for higher bandwidth is primarily driven by download and streaming of video and music, and the speed has increased rapidly within the past two years, so that more than half of the connections now have download rates of 10 Mbps or more. In 2008, less than 20% had a capacity at that level.

The demand for dual play (telephony and Internet access) and especially triple play (telephony, Internet access, and television) has increased rapidly within the last few years. The number of triple play connections has increased from 23,000 in 2008 to more than 180,000 in 2010 (ITST, 2011).

Figure 5.1: Broadband subscribers by download capacity, 2008-2010



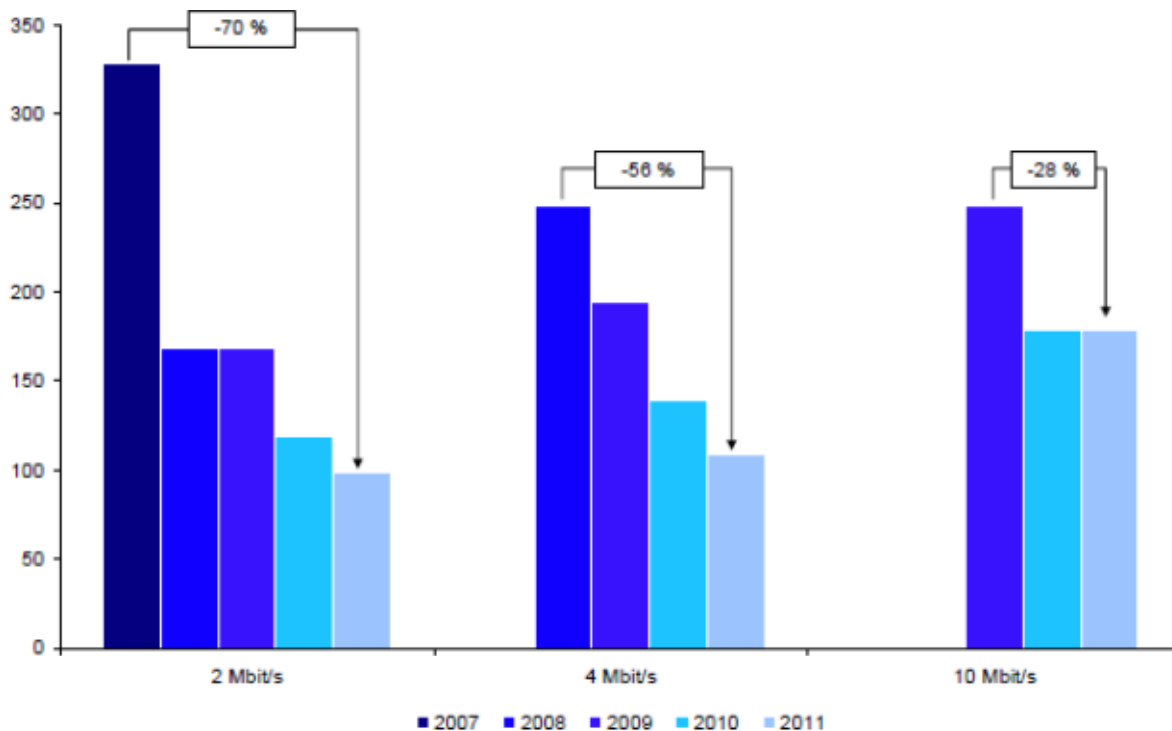
Source: ITST

Mobile broadband has achieved a high level of penetration within short time. So far, mobile broadband is used as a supplement to fixed broadband. Mobile subscribers tend to keep their fixed connection but this may change when LTE will gain importance within the next five years.

5.4 Trends in end user prices

End user prices have fallen rapidly within the past decade. The monthly charge for a 2 Mbps connection has fallen from app. 995 DKK (133 €) in 2001 to app. 99 DKK (13 €) in 2011. In general, it is the prices for high bandwidths that have fallen most so that price differences between high and low capacity services decrease over time. Price decreases have been accompanied by a parallel increase in bandwidths offered. The operators have often upgraded their customers to a higher bandwidth without changing the rate of subscription. In this way, ARPU has remained the same.

Figure 5.2: Price development on the retail market for broadband by download capacity (DKK per month), 2007-2010



Source: ITST

Competition on the wholesale market

TDC is as the incumbent operator by far the largest supplier of physical broadband infrastructure. TDC is the only provider of a copper based infrastructure covering covers 99% of all households. TDC possesses also the largest cable network covering 56% of the households (homes passed). And, since 2003 they have laid down fiber tubes, whenever a new building has been raised, and they own an extensive fibre network of 45,000 km.

TDC follows a strategy where copper based facilities gradually are replaced by optical fibres, and the DSLAMs are moved closer to the customer. In this way, it becomes possible to provide xDSL services at still higher bitrates without providing a full FTTH solution. By the use of vectoring technology, TDC will be able to provide 100 Mbps and later up to 250 Mbps through the existing copper cables. TDC expects that the market share of copper-based solutions will decrease, although copper will still have a role to play in 2020 (Computerworld, 13 October 2011).

TDC provides FTTH as well. In November 2009, TDC acquired DONG Energy's 7,000 km fiber network with 15,000 end users in the capital region. With this network, TDC now has a fibre

network, which covers 200,000 households (homes passed). This number will increase to 500,000 in 2020.

In addition to DONG Energy, other electricity companies have since 2000 invested in fibre networks, and their networks pass 700,000 households. Approximately 200,000 customers are connected or are about to be connected. However, due to sluggish demand, the electricity companies have since the economic downturn starting in 2008 scaled down their investment activities and focus instead on getting more customers connected to the existing infrastructure.

COLT Telecom is an international company. They operate their own fibre network in Copenhagen and provide wholesale services and retail services to business customers. GlobalConnect is another entrant that has been on the market since 1998. They provide dark fibers on a wholesale basis.

Stofa is the second largest provider of cable infrastructure. Stofa was owned by TeliaSonera but became independent in 2010 and is now owned by a Swedish investment fund. Their infrastructure covers major cities especially in Jutland and Funen. There is little overlap with TDCs cable network and the competition between the two is limited.

Wireless fixed infrastructures do not yet play any significant role at the Danish broadband market. Skyline provides 30,000 fixed wireless connections in their network (2010 figures). Regarding mobile broadband, on the other hand, there is high uptake. But so far, mobile broadband seems to function as a supplement and not as an alternative to fixed broadband. However, this may change in the immediate future with the introduction of LTE. Telia was the first operator to introduce LTE services on the Danish market and their strategy is to market mobile broadband as an alternative to fixed broadband. The selling of their cable business in 2010 can be seen as part of this strategy.

In spite of the good coverage of several infrastructures there is still a way to go before one can say that the broadband market is a market with real facility based competition. TDC has high market shares in all available platforms, and it has a dominating position in almost all geographical areas. However, the introduction of LTE may change this picture as this will enable all of the four mobile network operators to build their own vertically integrated broadband infrastructure.

5.5 Competition on the retail market

The retail market for broadband is dominated by the same operators as the market for physical broadband infrastructures in spite of the efforts made to separate the two markets through demand of open access. Table 5.4 shows that external sales of broadband access – excluding bitstream access - only constitute a small share of total sales. This indicates that bitstream-based competition only to a small extent develops into types of competition higher up on the rungs of the ladder of investment.

Table 4: External sale of broadband access (percentage of total sale), 2008-2010

	Copper	Fibre	Cable	Total
2008	6.5	9.7	0	5.4
2009	8.2	9.4	0	6.4
2010	7.8	7.9	0	6.0

Source: IT & Telestyrelsen: Engrosmarkedet for fysisk netværksinfrastrukturadgang (marked 4). 30 September 2011.

Early developments on the Danish broadband market clearly illustrate the strategic advantage related to ownership of physical infrastructure. xDSL was in Denmark first introduced by Cybercity. TDC was not very eager to introduce this service, as they wanted to protect their market for services charged per minute such as ISDN. At the turn of the century, the xDSL market was shared among three operators each having a 30-40% market share. In 2000, TDC initiated an aggressive promotion of their services by substantial reductions in prices, and in two years' time, TDC's market share increased from 30% to 79%. TDC was accused of predatory pricing but when the case was resolved it was too late for the two new entrants to regain their former position.

For all fixed platforms combined, the level of competition is below the European average. The TDC market share in fixed broadband connections is 63%, while the average market share for incumbent operators is 44%. Moreover, the TDC market share has remained fairly constant for the past 5 years. One reason for this is that TDC is a dominant provider on all technical platforms except for fixed wireless. The Danish market differs thus from the rest of Europe, as Denmark is the only country, where the incumbent dominates cable as well as xDSL services.

Table 5.5: Incumbent market shares – DSL access and broadband access total, 2003-2010

		Denmark	EU average (EU27)
DSL access	2003	82.1	77.9
	2008	67.5	55.9
	2010	73.0	55.0
Total	2003	67.9	58.7
	2008	59.0	45.6
	2010	63.1	44.0

Sources: *Telecom statistics – first half of 2003* National IT and Telecom Agency, Denmark, EU Commission: *Broadband access in the EU: situation at 1 July 2008* COCOM08-41 FINAL DG INFSO/B3 Brussels, 28 November 2008 and *statistics. EU Commission: Broadband access in the EU: situation at 1 July 2010*, COCOM10-29, DG INFSO/C4, Brussels, 21st November 2010

TDC has a market share of more than 73% for xDSL and 66%¹ on the market for broadband via cable (compared to the European average of 3.1%). TDC has been able to maintain a high market share partly because they have acquired some of the most successful of the new independent actors on the broadband market. This includes Fullrate and A+. Both companies provided xDSL services using the TDC infrastructures and both were acquired by TDC in 2010.

Apart from TDC the only providers with a significant market share on the xDSL market are, at present, Telia and Telenor. Telenor Denmark is with a turnover of 900 mill € in 2010 the second largest provider of broadband and telephony in Denmark. Telenor is first of all a mobile operator on the Danish market but they have achieved a position as a major provider of broadband services by acquisition of Cybercity in 2005. Cybercity was established in 1995 and had up to 2000 a higher market share than TDC on the xDSL market. In 2010, Telenor had around 75,000 xDSL customers, and they also have a minor share of broadband customers via cable (3%). However, they do not have their own copper infrastructure but rely entirely on TDC's access network for the provision of xDSL services.

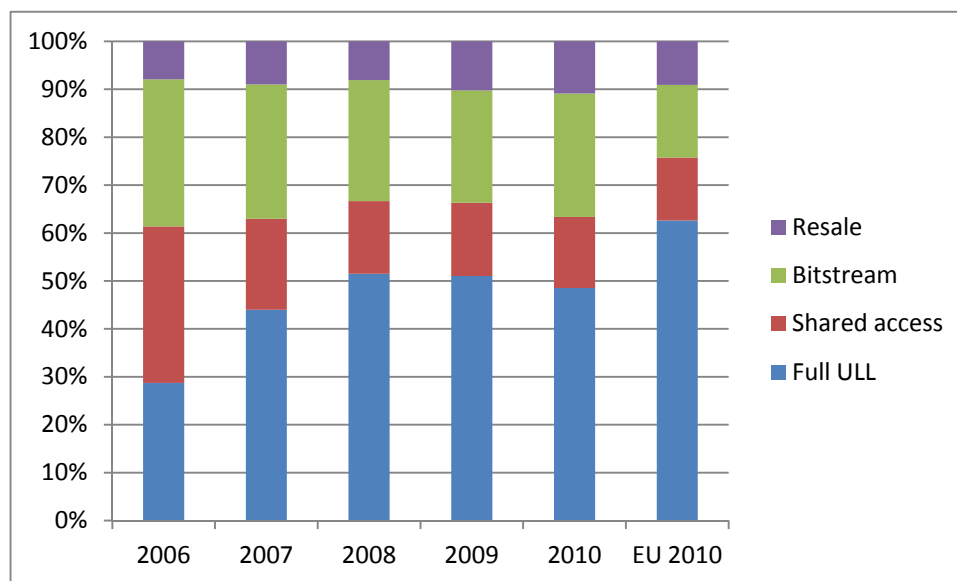
Telia Denmark is a part of the Swedish/Finnish incumbent telecommunication operator TeliaSonera and is the third largest telecommunication operator on the Danish market with a turnover of 760 mill € in 2010. Until recently, they had their own cable infrastructure, as they owned the Danish cable operator Stofa. In 2010, however, Stofa was sold to a Swedish investment fund.

From 2006 to 2009, new entrants on the xDSL market have climbed up of the investment ladder as new entrants have increased slightly their use of full unbundling compared to the use of bitstream access. Thus full unbundling of the local loop increased from 62% to 68%, while bitstream access decreased from 31% to 23%. However this development has reversed in 2009-2010. Here the share of bitstream access has increased to 26%. This development deviates from the general trend within the EU. Here, the number of full unbundling has tripled within three years, while the numbers of shared access, bitstream and resale have remained constant.

It is likely that the share of full unbundling will decrease as a result of future upgrades of the infrastructure. As TDC moves the DSLAMs closer to the customers in order to be able to provide more capacity to each subscriber, the business case for new entrants to use raw copper become less attractive. New entrants will need to make substantial investments in additional equipment, and when the number of potential customers decreases to 100-150 customers per DSLAM in total for all operators the payback time will be 10 years or more. New entrant may, therefore, either climb down the ladder again or make use of other technologies for provision of last mile connectivity.

¹ The 66% is the market share, while the previously mentioned 56% is the share of homes passed.

Figure 5.3: Unbundling, 2006-2010



Sources: *Bredbåndsredegørelsen 2010*, National IT and Telecom Agency, Denmark and EU Commission: *Broadband access in the EU: situation at 1 July 2010*, COCOM10-29, DG INFSO/C4, Brussels, 21st November 2010

At the cable access market Stofa is with a market share of 26% the second largest provider of broadband via cable.

The most important provider of broadband via fiber is Wao!. Wao! was formed by the electricity companies in September 2010 in order to promote broadband services via their fiber infrastructure. The company had in 2010 155,000 customers and a revenue of 18 mill €.

5.6 Future perspectives

Denmark has an advanced market for broadband connections in terms of coverage and penetration. Most parts of the country are covered with more than one infrastructure and for two thirds of the population, download speeds at 50 Mbps or more is available. The penetration is among the highest within in the EU and in the world.

The ambition of realizing real competition on the broadband market has, however, not been realized. The incumbent operator TDC dominates on almost all platforms and their market share is higher than the EU average market shares of incumbent operators within EU. Efforts have been made to compensate for TDC's dominance with regard to ownership of infrastructures by demanding open access not only to the copper network but also to cable and optical fiber networks. In spite of this it is likely that TDC will become even more dominant on the xDSL market, when the optical part of the network is expanded and the DSLAMs are moved closer to the customer. There is definitely more competition at the service level than at the infrastructure level,

but real service based competition can only be found in the mobile market, where competing fully integrated infrastructures are available.

Real competition will not be achieved before competing infrastructures are available. This was realized already a decade ago, when the 'several pipes to the home' strategy was announced. But more pipes do not help if TDC is able to maintain a dominating position on all platforms.

The electricity companies and their broadband provider Wao! provides a real alternative to TDC, but only in certain areas. Within the past two years, they have scaled down their ambitions and it will take some time before – if ever – they provide an alternative with national coverage.

In the immediate future the competition will mainly come from mobile broadband. So far, mobile broadband is seen as a complement and not a substitute for fixed broadband. This may, however, change with the introduction of LTE, which can offer a capacity sufficient for a major share of the customers. An analogy can be made to the introduction of mobile telephony. In the initial phase, the availability of mobile phones led to more traffic also in the fixed network, but later on the traffic began to move from the fixed to the mobile part of the network. Telia seems to have adopted a strategy, where they will focus primarily on mobile broadband and market this service as an alternative to fixed broadband services.

It should, however, be noted that triple play – a service which increases in importance – may delay this development, as it is not likely that the mobile networks will have the capacity to cover the need for TV services in the foreseeable future.

6. Use of Internet

The present section briefly examines what Internet and thus broadband is used for. This is the other side of the coin – so to say. One thing is having knowledge concerning the coverage and penetration of broadband; another thing is knowing what broadband is used for. There is, however, not total synanimity between broadband and Internet use. There is still a limited number of dial-up and ISDN connections left – especially among small business users.

Following the structure used by the Danish statistical bureau, Statistics Denmark (**source**), users are divided in three categories: The population as such, business users, and users in public institutions.

6.1 Population

First, an overall picture of the percentage of the Danish population using Internet is given.

Table 6.1: Percentage of the population (age 16-74) using Internet, 2002-2010

	2002	2004	2006	2008	2010
Daily or almost daily	38	53	65	71	76
Weekly	18	16	13	10	10
Monthly or more seldom	7	5	4	4	2
Total	63	74	82	84	88

Source: Statistics Denmark

These figures are higher than the EU-27 average, which in 2010 was 69%, including daily, weekly and monthly users. Furthermore, the Danish 2010-figure is slightly lower than the average for Nordic countries, with Finland at 85%, Sweden at 91%, and Norway at 93%.

With respect to applications, sending and receiving e-mails, Internet banking, e-tailing, and social networks are the most popular uses, see table 6.2.

Table 6.2: Use of Internet applications, percentage of population (age 16-74), 2005-2010

	2005	2006	2007	2008	2009	2010
Sending or receiving e-mails	69	74	74	76	81	83
Internet banking	49	57	57	61	66	71
E-tailing, i.e. buying goods or services on Internet	-	-	-	47	50	54
Listening to web-radio and/or watching web-TV	19	27	34	37	42	40
Uploading user-created content, such as text, pictures, film, music, etc.	-	-	-	14	33	37
Member of social network services	-	-	-	-	42	54

Note: Use means use during the last 3 month period.

Source: Statistics Denmark

One of the important applications constituting a reason for the uptake of broadband is Internet banking. When comparing Denmark with the EU-27 average and the other Nordic countries, Denmark is well ahead of the EU-27 average but somewhat behind other Nordic countries (see table 6.3). With respect to e-tailing, Denmark is likewise ahead of the EU-27 average and also a little ahead of the other Nordic countries (see table 6.3).

Table 6.3: Use of Internet banking and e-tailing in Nordic countries and EU-27, percentage of population (age 16-74), 2010

	Denmark	Finland	Iceland*	Norway	Sweden	EU-27
Internet banking	71	76	72	83	75	36
E-tailing	54	41	27	53	50	31

*: 2009 figure

Note: Use means use during the past 3 month period.

Source: Statistics Denmark

6.2 Business users

In the section on coverage and penetration, the business segment was not specifically dealt with. The 2010, broadband take-up figure for Danish business users was 88% including fixed and mobile broadband. This level is similar for all different business areas with a take-up rate above 80% in all areas. Size matters a little, so that small companies with 10-19 employees have a take-up rate of 84%, while larger companies with more than 100 employees reach 97%.

Regarding access technologies, xDSL dominates, but mobile broadband is catching up quickly. In 2010, 65% of companies in Denmark had a xDSL connection; 43% had mobile broadband; 31% had another (than xDSL) fixed connection, and 20% had another mobile connection; 18% had an old-fashioned modem connection or an ISDN connection (kilde)².

When looking at the use of broadband, 48% of Danish enterprises had been buying goods or services online during the past year in 2010. This is well beyond the EU-27 average and online buying in Finland and Iceland among the Nordic countries. However, Norway tops the list with 57% and Sweden is second with 53%.

The issue of electronic invoicing was mentioned in the section on public policies – the reason being that the Danish government decided that by 2008, public institutions would only receive electronic invoices. This should increase the efficiency in the handling of invoices, but would also be an incentive for companies to take up electronic data communications and, therefore, broadband. As it turns out, the use of electronic invoicing among Danish companies clearly topped the European list in 2008 but has since then decreased a bit while the use of electronic invoicing has kept on increasing in other European countries, among them the Nordic countries (see table 6.4).

² The take-up figures add up to more than 100%, as companies can use different broadband connection at the same time.

Table 6.4: Share of companies using electronic invoices, 2007-2010

	2007	2008	2009	2010
Denmark	37	43	38	39
Finland	27	25	24	36
Norway	29	31	32	47
Sweden	18	17	25	28
EU-27	18	21	23	32

Source: Statistics Denmark

The interpretation of this table must be that at the time of the decision in Denmark that public institutions would only receive electronic invoices, this had an effect on total use of electronic invoices, while this effect decreased slightly afterwards. In other countries, the numbers have increased much lately (from 2009 to 2010), especially in Norway that in 2010 headed the list.

6.3 Public institutions

With respect to public institutions, we will here touch upon communications between citizens (the population) and companies, on the one side, and public institutions, on the other. We will also look at communications between public institutions, i.e. government-to-government communications. When examining communications between the citizens and public institutions, Denmark is in the front with respect to information retrieval as well as download of forms and sending information to public institutions. Only Norway and Sweden get close, succeeded by the Netherlands, Finland and Estonia.

Table 6.5: Electronic contacts with public institutions, percentage of population and Internet users (age 16-74), 2010

	Denmark	Finland	Norway	Sweden	EU-27
Information retrieval (% of population)	68	49	62	57	28
Download of forms etc. (% of population)	39	36	39	36	18
Sending information to public institutions (% of population)	50	28	34	32	13
Information retrieval (% of Internet users)	78	57	67	63	41
Download of forms etc. (% of Internet users)	44	42	42	39	26
Sending information to public institutions (% of Internet users)	56	32	37	35	19

Source: Statistics Denmark

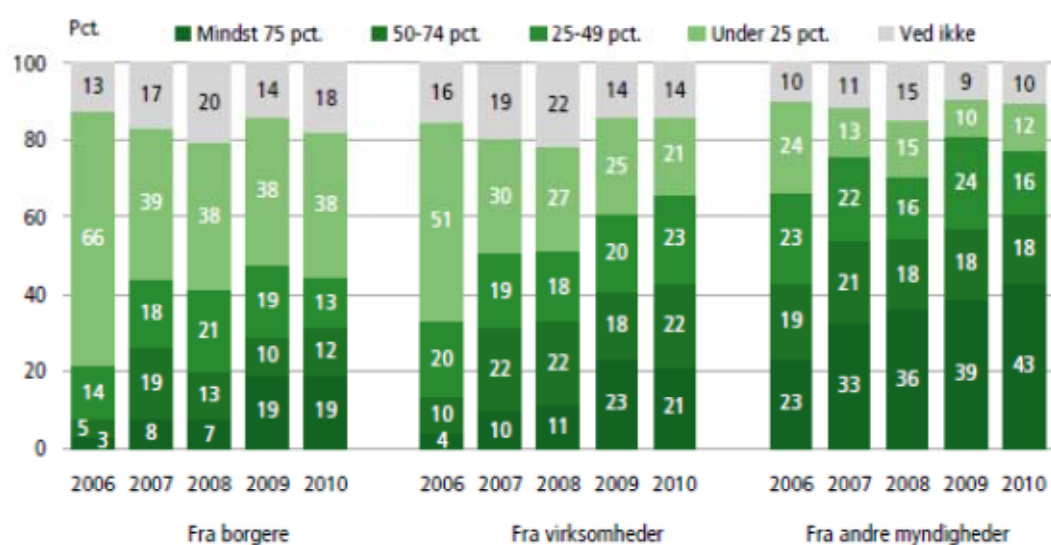
It is interesting to see that the difference between the figures for Internet users and the population as such is generally bigger in Denmark than the other Nordic countries. It is only natural that this difference is relatively big for EU-27, as the percentage of Internet users is smaller in EU-27 than the Nordic countries. While the take-up rate in EU-27 is 70% of families in EU-27, the corresponding figures are 90% for Norway, 88% for Sweden, 86% for Denmark, and 81% for Finland. The fact that the difference between the figures for Internet users and the population as such is bigger in Denmark compared to the other Nordic countries is thus not related to smaller Internet take-up in Denmark. The figures indicate that electronic contact with public institutions is more important for Internet take-up in Denmark relative to the other Nordic countries.

With respect to receiving documents in electronic format by public institutions, there has been a sharp increase during the past 5 years in Denmark. Figure 6.1 shows that this applies to documents from citizens as well as companies and between public institutions.

Figure 6.1: Share of documents received electronically by public institutions, 2006-2010

Source

Figur 1. Andel dokumenter der modtages elektronisk



Anm.: Ved 'dokumenter' ses der bort fra uformel e-post (fx korte meddelelser, svar m.m.). Det skal understreges, at der ikke er tale om en eksakt måling af modtaget e-post m.m., men derimod om et skøn fra myndighedernes side.

Source: Statistics Denmark

All in all, the figures relating to communication with and between public authorities show that electronic communication increasingly plays an important role. How this affects the take-up of

broadband – or rather what the relationship between the use of electronic applications and services and the take-up of broadband is – does not come out of the figures themselves. But it must be assumed that there is a mutual correlation. Increased take-up of broadband will lead to growing use of electronic applications and services and vice versa. The high penetration of broadband in Denmark is closely correlated with the pervasive use of electronic services. This provides policy intervention with different handles on the development of broadband – either via supporting broadband development or via support for electronic services, or both. In Denmark, support for electronic services has been chosen.

7. Discussion and conclusion

The penetration of broadband in Denmark is among the absolutely highest in the world. However, the most common broadband speeds are at an average level and the prices are not among the lowest. In the paper, focus is on coverage and penetration.

Two issues are specifically in the focus of attention. One issue relates to the policy emphasis on services and applications and, consequently, on factors on the demand side of the uptake of broadband access. The other issue is concerned with the situation in Denmark, where the incumbent operator, TDC, offers broadband access on all major platforms – xDSL, cable, fiber, and mobile. The result is that the incumbent operator has a comparatively strong market position in Denmark. The result is also that the interconnection and access regulation in Denmark not only encompasses copper, among the fixed-line technologies, but also cable and fiber.

Although the policy emphasis on the demand side is not a unique Danish feature, this approach has played a big role in broadband policies in Denmark. The paper is thus aiming at putting emphasis on broadband questions, which are either specific or prominent in the Danish broadband story.

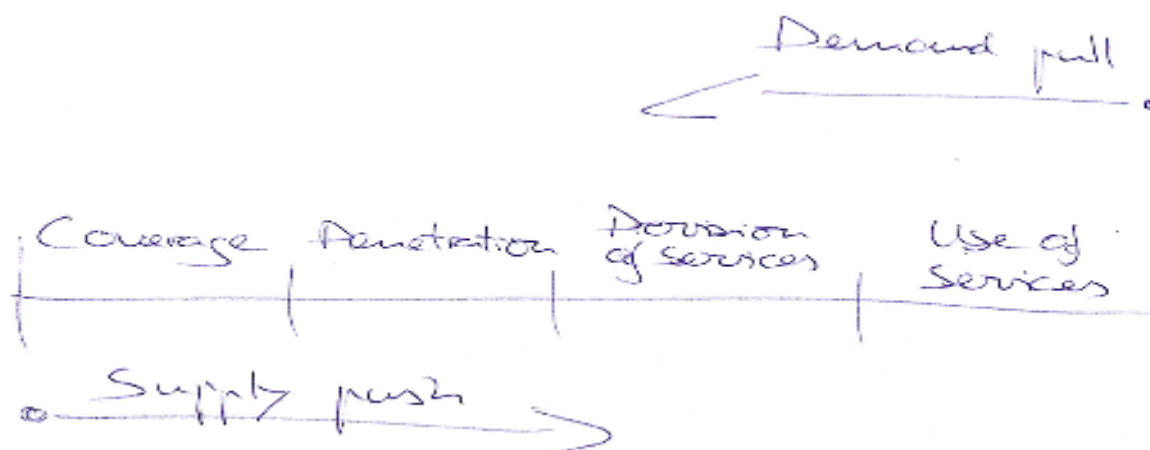
In addition to these two primary issues, two other aspects play a significant role in the paper - one regarding the kinds of operators on the Danish market and another concerning the periodization of broadband developments in Denmark.

7.1 Policy emphasis

Coverage, penetration, provision of services, and use of services are all parts of the total picture of broadband development, and broadband development policies can relate to all four aspects. Indeed, broadband policies in Denmark relate to all four aspects, however, with an emphasis on policies regarding penetration and provision of services. But access and interconnection regulation also affects the infrastructure build-up of operators, and policies for the promotion of use of services delivered on broadband networks are also part of public policies.

Figure 7.1 illustrates the four different aspects of broadband development and the supply push and demand pull forces in action.

Figure 7.1: Aspects of broadband development



Coverage is an issue, which in Denmark is basically left to the network operators presently. Apart from the indirect effects of access and interconnection policies on infrastructure build-up of operators, the only real current policy intervention concerning coverage is in the mobile field, where coverage requirements are part of the frequency assignment process. From a historical point of view, there are three instances where there has been public money involved in building up broadband infrastructures. The first instance was the so-called hybrid network in the 1980s, where a traditional industrial policy goal was part of this policy initiative. The second instance, which continues to develop, is the public research and education network. As in most other countries, the public research and education network has played a role in the general broadband infrastructure especially in the early phases of broadband development. The third instance is local authorities putting money into local network development initiatives in different municipalities.

Apart from such kinds of initiatives, the general policy since the liberalization of the telecommunication sector in Denmark in 1996 has been to leave it to the network operators to fund infrastructure expansion. This also applies to the present situation, where public economic support for broadband and bandwidth expansion is considered and implemented in different countries around the world. As a reaction to the international surge for broadband development following the financial and economic crisis starting in 2008, the Danish government in 2010 decided that everyone in Denmark must have access to a 100 Mbps connection by 2020. But there is no public money to back this goal up with. It's a mere message to the network operators that bandwidths should be expanded.

On the borderline, so to say, between coverage and penetration, we have universal service policies. Universal service policies can in principle be used for coverage as well as penetration purposes, where coverage is concerned with the access possibility and penetration with the access conditions including pricing. However, universal service policies have not been used for broadband purposes in Denmark. Potentially, the possibility for using universal service provisions in the broadband area is there in the telecommunication legislation. But they have never been in use for that purpose.

While coverage and the expansion of bandwidth – though surveyed intensely by the regulatory agency – has seldom been the direct focus of policy initiatives, policy emphasis has been on the promotion of penetration, i.e. broadband take-up. As penetration is a demand issue – it's up to the users to subscribe to a broadband service – the way penetration can be supported is by putting pressure on service quality and prices by way of competition policy, first and foremost access and interconnection policies, and by way of promoting services and the take-up of services by users. Penetration can also be directly supported economically, which is actually done in Denmark. If an employee of a company or public institution gets a broadband connection paid by the employer, there is an indirect tax support for this kind of arrangement.

It is the development and combination of these policy initiatives, which constitute the main components of Danish broadband politics. The politics regarding competition do not generally differ from similar politics in other European countries. There can be a timing issue but the major special characteristic of the Danish politics in this area is that all fixed infrastructures are subject to access and interconnection regulations obliging operators with significant market power to open their infrastructures to competitors.

The other main characteristic of Danish broadband related policies is the emphasis on the provision of public services requiring data or in reality broadband access and the pressure on citizens and companies to use these electronic services. Similar policies can be found in different forms and shapes in all European countries. However, in the Danish context such policies have not remained 'beautiful' but unrealized policy goals. In many instances, they have actually been implemented. This is of, course, partly due to political commitment but also to the social and institutional infrastructure for realizing such policies. Part of this social and institutional infrastructure is a relatively well-organized public sector with the possibility of making policy decisions, which have a bearing on all public institutions.

Another and compelling reason for the high penetration of broadband and widespread use of broadband-supported services is the relatively high GDP per capita. In section 6, comparisons with other countries regarding a few service areas are presented. The general picture is that Denmark is doing better than the EU-27 average – which, admittedly, includes a wide range of countries. However, when comparing with other Nordic countries, the level is about the same – in some instances a little ahead in other instances a little behind. This shows that although policies in the

area are important, the general social and institutional infrastructure including GDP per capita and its distribution is equally or even more important.

7.2 Dominant incumbent operator

The incumbent operator on the Danish telecommunication market, TDC, holds a very strong position in the broadband access area. Not only does TDC have a very strong position on the DSL market and a strong presence also on the mobile broadband market, but it also has a large stake in the cable access market and the fiber market.

While cable access was either an entirely separate business area in many countries from the beginning or was separated actively by the state when digital technologies and technical convergence allowed for the use of cable networks for broadband provision, cable stayed as one of the service areas of TDC. The story was that what came to be TDC took over the abovementioned hybrid network when this initiative was terminated. This is how TDC acquired a cable network, which was subsequently built out partly by including many of the small antenna cooperatives that had been formed.

On the fiber access market, the Danish story has been that the initiative to build fiber access networks was originally taken by electricity providers. They saw an opportunity to exploit their customer basis to offer fiber access in addition to access to the electricity grid, and the strategy was originally to offer a full package of services comprising the physical access infrastructure as well as content and communication services. This strategy has, however, turned out to be difficult to realize, and electricity companies nowadays offer a fiber connection and cooperates with communication and content providers to offer the full package. The policy of TDC has primarily been to move its fiber infrastructure progressively closer to the end user without having a general offer of fiber access all the way to the home. However, in 2009 TDC bought the fiber operation of the large electricity provider DONG and has thus entered the fiber access market on a larger scale.

It applies to all broadband access infrastructures that the incumbent TDC has not been the first mover. This has been the case with DSL as well as cable, fiber and mobile. TDC has in all cases been the second or third mover but has so far managed to become either the largest broadband provider or one of the largest access providers on all platforms.

The result is a very concentrated broadband access market in Denmark. At different instances, the European Commission has praised Denmark for its competitive telecommunication market. However, when looking at the broadband market as such, there is not much reason to praise the competitive situation. The aggregate market share of the incumbent is well beyond the European average.

As in all other European countries, the public policy to deal with such an unequal situation has been to implement an ex ante competition policy for access and interconnection. The idea has

been to create service competition using the networks of the incumbents and then rely on alternative operators to invest in their own infrastructures along the way. A theoretical version of this policy has been entitled the 'ladder of investment' – assuming that when an operator has a sufficiently strong position on the service market, it will eventually invest in its own infrastructure. Although steps in direction of such a development have been seen, the overall conclusion is that it does not work this way – or that the rungs from full unbundling to investment in one's own infrastructure is too far apart. In the Danish context, one can even see a reversal of this development. Bitstream access has lately been advancing as opposed to full unbundling.

All the while, it has been the policy that infrastructure competition is 'better' and more sustainable than service competition. In Denmark, this policy has been entitled 'many pipes to the home'. Though this heading does not spell out who the providers of these pipes should be, the presumption has been that there would be different competing infrastructure providers.

This also applies to some extent, namely in the cable, fiber, and mobile areas, while DSL is almost entirely the prerogative of TDC. However, in contrast to most other countries the incumbent TDC is present on all significant infrastructures. This constrains competition and has lead Danish legislators not only to regulate access of competitors to offer DSL based services on the PSTN of the incumbent but also to open access to the cable and fiber infrastructure. This is not in line with the general policy of the EU in the area, as the EU wishes to support infrastructure provision by allowing investors in new infrastructures to keep such infrastructures for themselves if they so wish. However, in the Danish situation with a presence of the incumbent on all infrastructures, the Commission has chosen not to intervene.

There is, as mentioned, general agreement that infrastructure competition is more sustainable than service competition. But the latest developments could lead to a strengthening of this assessment. Not only is infrastructure competition more sustainable but it is also necessary for the sustainability of service competition.

7.3 Operators on the Danish market

The incumbent operator – first named Tele Danmark and later TDC - was created by a political initiative in 1990 as a holding company owning the four regional monopolies and one international operator that existed at that point of time. A basic incentive for establishing a national operator was to create a strong Danish player that could act in the international competitive environment, which one could foresee, was on its way. The irony of the matter was that a large share of the total stock with a dominant influence was later sold to a foreign operator, the American operator Ameritech subsequently to be merged with another American operator SBC. Later in the process, in 2005, a group of private equity (PE) companies took over 87.9% of the TDC stock – a share that in 2010 was reduced to 59.1%, which the PE companies are presently planning to sell when the right opportunity comes.

How this PE ownership has affected TDC has been subject to discussion. However, for the Danish telecommunication users, it is not obvious that the PE take-over has significantly changed the course of development. The PE companies have sold off most of the international operations of TDC and have turned TDC into a company operating primarily on the Danish market. During the past decade, the two other large incumbent Nordic operators, TeliaSonera and Telenor have become sizeable international players, while TDC has shrunk to basically a national player. But for the users in Denmark, the most significant implications have possibly been that TDC has continued the course, which was laid in the Ameritech/SBC period, i.e. to continue to be a second mover with respect to new network solutions on the Danish market and not to use the Danish market as a test bed for wider international initiatives.

Apart from TDC, the three other largest operators on the Danish market are the other Nordic incumbents, TeliaSonera (on the Danish market operating under the brand name of Telia) and Telenor, and the operator 3 in the mobile area. All four operators (TDC, Telia, Telenor, and 3), presently, have their own mobile networks. However, Telia and Telenor in 2011 announced that they would join their mobile networks in order to strengthen their position on the Danish market. Telia as well as Telenor also offer DSL services, basically using the network of TDC. And up until recently, Telia also owned the cable operator Stofa, which 2010 was taken over by a Swedish private equity company. There is thus a development trend in Denmark in direction of a situation, where the incumbent Danish operator is the all-dominant network operator in the fixed network market segments, while network competition is on the mobile market. In the fiber area, local electricity companies are active, but they have clearly scaled down on their ambitions and TDC has become a significant player with the take-over of the fiber access network of the electricity company DONG.

There is a considerable number of broadband service providers on the Danish market – in the xDSL field as well as the mobile area. The development pattern, which has been seen at numerous instances, is that service providers start operating with cheaper and more attractive pricing schemes for the users than the existing operators. They grow to a considerable size, running with an increasing deficit but with a quickly developing number of subscribers. Finally, they are bought up by one of the large network operators, which are both interested in the subscriber stock of the service providers and also do not want to see them being taken over by one of competitors.

7.4 Periodization and final remarks

The first phase of broadband development in Denmark came with the initiative to establish the so-called hybrid network in 1985. The objective was to provide residential customer with TV programming and business users with high-speed data channels. The objective was also to support ICT companies based in Denmark with such a kind of public procurement policy. The initiative was inspired by similar projects in other European countries, but was an isolated Danish initiative.

The following phases in the broadband developments in Denmark are closely related to the EU policies in the area. Up until 1996, the telecommunication market was still basically a monopoly market except for areas considered as peripheral such as mobile communication. However, in 1995 the Danish government decided to liberalize the Danish telecommunication market 18 months ahead of the 1998 EU liberalization deadline.

At first, the primary focus was still on the narrow band markets, primarily telephony. However, this gradually changed, and the late 1990s is the period where broadband took off market-wise and in policy and regulation. ADSL was introduced to the Danish market in 1997 and soon became the preferred broadband access technology. This put emphasis on service competition but the deployment of different infrastructures was concurrently promoted politically – as seen in the policy for ‘several pipes to the home’ included in the policy agreement of 1999.

Broadband policy in Denmark has not experienced any sharp turning points regarding the emphasis on service vs. infrastructure competition. The policy could be described as an attempt to ‘walk on two legs’. The policy agreement of 1999 is still the basis of telecommunication policies in Denmark. This stability in telecommunication policies is mirrored in a similar stability in the broader ‘information society’ policies including the policies on the promotion of services and applications requiring broadband access.

Lately, two trends in broadband policies have been seen internationally. One trend is to boost the development of broadband by the use of public money in broadband development. The other is to promote private investment in new broadband infrastructures by limiting the rights of access to new infrastructures of operators competing with network owners. However, none of these trends have been seen in Denmark. It has been consciously avoided to put public money into broadband development – even though there is a political pressure on operators to upgrade their networks to higher speeds. And, all fixed broadband infrastructures are subject to access and interconnection regulation.

There is thus nothing that presently signals any sharp change in the Danish broadband development. A gradual development with increasing speeds on xDSL and cable networks and with a growing number of fiber access customers is envisioned. The only thing that presently seems to be able to change this relatively stable development is mobile broadband. This is where the competitors to TDC put their emphasis and trust.

8. References

- Cave, M.: (2006). Encouraging infrastructure competition via the ladder of investment. *Telecommunications Policy*, 30(3-4), 223-237.
- CEC (2007). *Impact assessment on the proposal to amend the European regulatory framework*. Working document – SEC (2007) 1472. Brussels: European Commission.
- Commons, J.R. (1934). *Institutional Economic: Its Role in Political Economy*. New York: Macmillan.
- European Commission: Telecommunications Regulatory Package – VIII Implementation report – Annex I – Corrigendum March 2003
- Economist Intelligence Unit (2010). *Digital Economy Rankings 2010*. London: The Economist.
- European Commission (2010). *A Digital Agenda for Europe*. COM(2010) 245 final/2. Brussels, 26.8.2010.
- European Commission: Telecommunications Regulatory Package – XII Implementation report – Annex I, 2010.
- Falch, M. (2002). TELRIC – the way towards competition? A European point of view. *Review of Network Economics*, 1(2), 6.
- Falch, M. & Henten, A. (2009). Achieving Universal Access to Broadband. *Informatica Economica*, 13(2), pp. 166-174.
- Falch, M. & Henten, A. (2010). Public Private Partnerships as a Tool for Stimulating Investments in Broadband. *Telecommunications Policy*, 34(9), pp. 496-504.
- Højhastighedskomiteen (2010). *Danmark som højhastighedssamfund* (Denmark as high speed society). Copenhagen: National IT and Telecom Agency.
- IT & Telestyrelsen: IT og telepolitisk redegørelse 2010
- IT & Telestyrelsen: Analyse af engrosreguleringen på bredbåndsmarkedet, 13. december 2010.
- IT & Telestyrelsen: Engrosmarkedet for fysisk netværksinfrastrukturadgang (marked 4). 30. September 2011.
- Kim, Y., Kelly, T. & Raja, S. (2010). *Building Broadband: Strategies and Policies for the Developing World*. Washington D.C.: World Bank.
- Koppenjan, J. & Groenewegen, J. (2005). Institutional Design for Complex Technological Systems, *International Journal of Technology , Policy and Management*, 5(3)3, pp. 240-257.

Melody, W.H. (2007). Markets and Policies in New Knowledge Economies, in Robin Mansell et al (eds.): *The Oxford Handbook of Information and Communication Technologies*, Oxford University Press, pp. 55-74.

NITA (2010). *Ambitious New Broadband Goal for Denmark*, 15 June 2010. Copenhagen: National IT and Telecom Agency.

North, D. (1986). The New Institutional Economics, *Journal of Institutional and Theoretical Economics*, 142, pp. 230-237.

OECD (2011). *OECD Broadband Portal*.

http://www.oecd.org/document/54/0,3343,en_2649_34225_38690102_1_1_1_1,00.html

Prehn, O. (1986). Hybridnettet er på vej - stadigvæk. status over etableringen af et dansk hybridnet. *MedieKultur. Journal of Media and Communication Research*, 2(2)

Veblen, T. (1973). *The theory of the leisure class*. Boston: Houghton Mifflin. (First published in 1899).

World Economic Forum (2011). *The Global Information Technology Report 2010-2011*. Geneva: World Economic Forum.

Østergaard, B.S. (1986). Politik og økonomi bag beslutningen om et dansk hybridnet. *Politica*, vol. 18, issue 4